Summary of the Standby Power Workshop

Sponsored by the California Energy Commission (CEC)
and Public Interest Energy Research (PIER)
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Clark Kerr Conference Center, University of California
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About fifty people attended the workshop. Almost half of the participants represented important segments of the electronics industry, but there were also people from the appliance industry, the California Energy Commission, and other interested groups. International participation consisted of people from Mexico, China, Thailand, Denmark, France, Japan, and Texas. A list of attendees is available here. Jim McMahon of LBNL chaired the workshop.

Commissioner Arthur Rosenfeld opened the workshop with a reminder of some of California's energy problems and his long-standing interest in standby power. He emphasized that that the purpose of this workshop was to identify and recommend areas where CEC-sponsored research could help the CEC develop appropriate policies.

Jim McMahon explained that he wanted the group to focus on research in three specific areas: (1) measurement; (2) technology; and (3) programs. Specific programs, such as standards, incentives, or labels were *not* the topic, but the research necessary to make informed policy decisions was to be the principal topic for discussion.

Morning Presentations

Bruce Nordman of LBNL introduced the key terms to the group.[2] It is important to define the terms because there are many different meanings for "standby" and other key terms. Without a clear and common understanding at the beginning, the group will be confused and waste time. In the electromechanical era, appliances had two operating modes, "on" (or "active") and "off". With the advent of electronics, a third mode appeared between "active" and "off." This is often called "standby" but has many other names depending on the device (or even the manufacturer of the device). Some devices have yet another mode—"sleep"—between standby and active. Future devices are likely to have many different operational modes between "unplugged" and "active", each with a different level of electricity use and functionality.

The focus of this workshop are the modes between unplugged and active, which we call the "low power modes". It is also important to distinguish between *operational* modes

[1] This summary relies on my notes and imperfect memory. In some cases I have grouped ideas that may not have been chronologically adjacent. I apologize for any incorrect attributions of comments.

[2] All presentations are available on the web at: http://standby.lbl.gov/CEC_Workshop/

(such as on, sleep, and off) and *power* modes, such as the definitions of standby adopted by the IEC, FEMP, and some other groups. The IEC and FEMP definitions of standby refer simply to the device's lowest power mode while connected to the mains, irrespective of functionality.

Alan Meier of LBNL presented a review of measurement, research, and programs related to standby power. Virtually all of the *measurements* have been conducted on standby power use in homes. Over one thousand homes around the world have been measured, including some in Europe, Japan, Australia, and China. Only one formal study in the USA has been conducted, consisting of 10 homes in California, so we have a poor understanding of both the California and US standby situation. Less information is available for other low power modes. The data situation is even scarcer in the commercial sector. No commercial buildings have been monitored, so we have essentially no idea how large low-power mode energy consumption is, let alone a list of devices with low-power modes.

Meier presented standby measurements from Australia, Japan, and California. With the available information, we cannot even determine if standby is increasing or declining. ENERGY STAR programs may be lowering standby in common consumer electronics but the rapid appearance of new, digital appliances and the dramatic increase in the number of appliances with standby may be offsetting those gains. Some of the key growth areas for residential standby include set-top boxes, white goods, and home networks. Another problem is "hard-wired" standby caused by smoke detectors, security systems, GFCIs, and HVAC control systems. A unique problem is digital converter boxes for TVs, which may be required for as many as 200 million TVs in the next 5 years, each drawing as much as 20 W.

Meier reviewed the *programs* around the world that deal in some way with low power modes. Voluntary and mandatory programs exist in North America, Europe, Japan, Australia, China, and a few other countries. Most of the voluntary programs, such as ENERGY STAR, deal with the standby mode (for consumer electronics) or sleep mode (for office equipment), but few try to capture all low power modes. Most of the mandatory efficiency programs, such as the white goods efficiency standards in the US, Europe, and Japan, target active modes and ignore the low power modes.

A technical committee of the IEC (TC 59 WG 9)[3] recently issued a draft definition and test procedure for standby power. The committee's responsibility is white goods, but the test procedure was designed to apply to virtually all electric devices that can be plugged in. Responsibility for definitions and test procedures of other low power modes is spread among many other international organizations and groups, with no overall organization or coordination.

Meier described some of the *research* strategies to reduce low power modes. There is only limited technical research focused on improving the efficiency of low-power modes.

[3] The Committee Draft is available at the workshop website.

The wide diversity of products partly explains the lack of specific research on the topic. Nevertheless, research that will impact low power modes is underway. Technologies borrowed from other situations can often be constructively applied to low power modes (such as battery-powered devices, where power consumption is critical). Some corporate research directed to other goals has also led to low-power solutions. For example, the need to reduce heat and weight of power supplies has resulted in greatly improved efficiencies for some products.

There are three principal research strategies to reducing the energy consumed in the low power modes:

- Improve the efficiency of the components
- Improve software to help equipment operation better match functional needs
- External improvements

An example of *component improvement* is increasing the efficiency of power supplies in their no-load and part-load performance. Other examples include de-energizing components when not needed and designing ultra-low power circuits.

Software improvements help the device better match operational components with functional needs. These improvements enable the device to shift operating time from active to sleep, from sleep to deep sleep, and from sleep to off. These changes may actually increase energy use while in the low power modes (by shifting operating time from active) but result in lower overall energy use.

External changes can also reduce energy use in low power modes. Important examples are the communications protocols between service providers (such as cable TV providers) and set-top boxes or between a server in a home network and the appliances on the network. In both cases, the protocols need to be designed to enable devices to enter the lowest possible operational state. This requires coordination between the service providers and the box manufacturers. Other external changes include construction of a low-power DC supply network in buildings (to eliminate the need for separate power supplies) and improved user interfaces that make low power modes easier for consumers to identify and allow to occur.

Finally, **Meier summarized estimates of the energy use of low power modes in California.** There aren't any. However, Meier offered a "best guess" of residential standby as 70 W per home, or about 10% of California residential electricity use. The more modest additional energy use of sleep modes must still be added to this number, so 70 W represents a conservative estimate. This corresponds to a California-wide load of about 900 MW (800 GWh/year). The rapid introduction of set-top boxes and other high growth appliances is likely to cause observable increases in statewide electrical demand. New homes are likely to have much higher standby electricity consumption because of these hard-wired components.

Data for the commercial sector are even sketchier, but it's possible that office equipment alone are responsible for 1100 GWh/year. Meier believes that the energy use of equipment in their low power modes is the fastest growing component of California electricity use.

Morning Discussions

Jim McMahon then asked the participants to identify themselves and briefly explain reasons for attending and any particular topic that they hoped the workshop would address. In addition, he solicited their views regarding CEC-sponsored research in the area of low power modes. There was a wide range of responses. A sample of the responses is given below.

Industry was well represented. Mike van Sickle of Whirlpool had been recently tasked to learn about standby power for his company. Cliff Walker and Kay Luo of Power Integrations—a major manufacturer of power conversion solutions–wanted simply to keep abreast of developments. David Cohn of IBM was coordinating a low-power initiative across IBM and mentioned battery-powered devices as a source of innovations for low-powered solutions. Dale Stolitzka of Analog Devices–a manufacturer of electronic components–stressed the need for a holistic approach, involving both technologies and consumers. Ian Miller of Samsung came to observe the discussions. He noted that Samsung designs products to meet the highest international standard so that it products are always compliant. Nayeem Sheikh of Cisco Systems described Cisco's internal efforts to reduce energy use and in particular low power modes.

A second group attended to gather information and learn more about the topic. Pramod Kulkarni of the CEC PIER program is in charge of industrial research. He was curious to see how much of the standby problem also applied to California industry. Tim Burke of Underwriters Labs was here to listen and be a potential resource. Dan Werthhimer, of UC's Search for Extraterrestrial Intelligence (SETI) Program gave the most unusual reason for attending. His program is responsible for keeping at least 5 million PCs on at night and he was concerned about how to reduce their energy consumption. Karl Brown of California Institute for Energy Efficiency (CIEE) noted that the estimated amount of standby electricity use was greater than that for street lights, which had already received considerable attention from the CEC.

A strong international perspective was contributed by participants from Europe and Asia. Peter Karbo of the Danish Energy Agency described a failed Danish program to interest consumers in buying low-standby products, including a free meter to measure standby power use. Karbo also mentioned that 10% of Danish homes already had routers installed, each drawing 20 W continuously, and that he expected saturations to rise rapidly. Benoit Lebot of the International Energy Agency stressed the international aspects of standby power and urged the group to consider the problems related to retrofit of existing equipment. Hidetoshi Nakagami, of the Jyukankyo Research Institute (Japan), explained how his group had become involved in measuring standby almost ten years ago and how low standby became a sales feature for some appliances. Peter duPont–working

out of Thailand's Electric Power Authority–described the inattention to standby power use in all of the Southeast Asian countries. Similar inattention in Mexico was echoed by Carlos Chavez of the Mexican Energy Conservation Agency (CONAE). Polly Shaw of the Energy Foundation described how China had recently discovered the size of standby and started its first program for TVs. Ruiying Zhang explained that China was the world's largest manufacturer of power supplies and that these devices represented a major end use of electricity in China.

Representatives of key manufacturers' associations also attended. Jason Linnell of the Electronic Industries Alliance described the EIA's commitment to participation in reducing low power modes, but stressed that the active modes should be left to the discretion of the manufacturers. In contrast, Gene Foley, of the Association of Home Appliance Manufacturers (AHAM) described his association's long involvement in regulation of active modes and wanted to ensure that manufacturers had the discretion to minimize energy costs over the whole operating cycle rather than respond to a standby-only specification.

The participants all seemed to agree that further research into the energy usage of low power modes was necessary, and none disputed the CEC's role in stimulating or supporting that research. The discussion then turned to the kinds of research that would be beneficial.

One theme was the need for more measurements in homes and commercial buildings. These studies needed to be sufficiently large to satisfy policy and forecasting requirements. A second theme was the need to better understand how power was actually used in the low power modes, and could be typified by the question, "Why do otherwise identical products have such a wide range of standby?"

A third theme was the need to get a better understanding of consumer behavior, including purchasing, operating, and need for specific features. Some believed that informing consumers would motivate them to purchase more efficient devices and operate them in a more efficient manner, such as occurred in Japan. Others doubted this, pointing to the failure in Denmark of a consumer awareness program.

Karen Herter (CEC) tried to reconcile two frequently raised research directions: investigation of components as opposed to analyses of whole products. Different strategies may be required for large and small products. For small products, a component-based research strategy (e.g. more efficient power supplies) may be more appropriate (because it would involve small improvements covering many devices with little effort; whereas an appliance-by-appliance approach on so many devices would be far too cumbersome). A holistic approach (i.e. a 24-hour duty cycle standard including standby and all other modes) may be more appropriate for larger, more complex, products that are responsible for a large portion of building energy use.

The need for appropriate energy test procedures and protocols to measure buildings was mentioned in several different contexts. Clearly measurement surveys of many buildings

cannot begin until test procedures and protocols are established. The test procedures must be carefully formulated in order to include unusual situations. Examples of the special requirements would be their ability to capture burst modes power supplies in displays and backwards power problems sometimes caused by switch-mode power supplies.

Lunchtime

During the lunch and coffee breaks, the group was able to view a display of products consuming standby power and see how much power each product drew in different modes. This was the same display viewed by President Bush that caused him to issue his executive order on standby power devices.

Afternoon Presentations

After lunch, the group reconvened to hear three short presentations. **Travis Reeder (Ecos Consulting) described his group's research into efficiencies of power supplies.** Power supply efficiency has major impacts on all modes, not just the low-power modes. Only about 1/4 of the total energy channeled through power supplies (both internal and external) occurred while the products were in low-power modes. Reeder stressed the key role of part load efficiency because most power supplies are greatly oversized and because standby and sleep modes draw only a small fraction of rated load. Large energy savings—in all modes—are potentially available through improved power supply efficiency.

Bruce Nordman (LBNL) summarized his CEC-sponsored research on standardizing user interfaces for controls related to power management. Less than a quarter of PCs have power management enabled. The goal was to promulgate a consistent set of icons, symbols, indicators, actions, etc., for controlling power status, including enabling power management in office equipment. In this way users would more likely enable power management (or even shut down) rather than keep the device in a higher, power-intensive mode. The project began with office equipment but applies to any digital electronic device that consumers interact with, such as consumer electronics. This is an example of the kind of research that, while not employing new technologies or increasing the device's cost, could have enormous energy savings.

Leo Rainer (Davis Energy Group) presented early measurements from a zero-energy home in Livermore, CA. The house is not yet occupied, so the regular complement of appliances has not been installed. Nevertheless, hard-wired standby–smoke detectors, GFCIs, the security system, a router, a garage door opener, irrigation timer, etc.–appeared to be already responsible for 60 W of standby power.

Afternoon Discussions

Jim McMahon led a discussion of research needs. The discussion was divided into commercial and residential research needs, but the conversation often crossed back and forth as the group recognized common situations or recalled another topic.

For *commercial* buildings, the group agreed that the first step was to visit buildings and establish a *taxonomy* of products with low-power modes. This taxonomy should also include devices that could be in a low-power mode but were not. The group repeatedly mentioned devices that might be overlooked, such as uninterruptible power supplies, emergency and security lighting, faucets controlled by motion sensors, telephone switches, etc. Some of the hardwired devices could be counted by examination of the building's blueprints, while others could only be identified through careful audits.

Measurements could follow the taxonomy. With this information and careful examination of individual products, it would be possible to identify potential savings with present or future technologies. This information could be combined to construct a *supply curve of conserved energy*, showing the statewide savings resulting from improvements to specific devices or components. A conservation supply curve would then inform policy-makers of the most promising areas for programs.

For residential buildings, the group felt that a taxonomy already existed, and that it was time to undertake measurements of a statistically significant sample. Ideally the study should continue over many years so as to learn if energy use in the low power modes was increasing or decreasing. It would also be important to sample both existing and new homes because new homes appeared to have special aspects. User attitudes and behavior in homes were perhaps more important than for commercial buildings. For example, how do consumers actually use the devices? (e.g., what gets unplugged? Power managed? If yes, for how long?). The need for a supply curve of conserved energy and technology-cost curves to guide program design was raised several times.

The group raised several specific technological problems/solutions that merited research, including, digital TV converter boxes, dedicated DC networks, hard-wired low-power energy use, and power buttons powered through USB connections.

The vital role of the power supply in both the low-power and active modes was mentioned many times through the morning and afternoon. The group wanted to know actual performance of power supplies, the fraction of linear and switcher power supplies, and potential savings from shifts to switching power supplies.

One theme raised in discussions for both sectors was the need for (and complexity of) a measurement protocol for low power modes. Many products wait or require a long time (hours) before they revert to sleep modes. One set-top box needed over 45 minutes to re-boot, so the measurement protocol must be flexible enough to wait that long. Measurement of power levels would be a relatively small portion of information collected. For example, the power level data must be combined with schedules, duration, and total building energy use before it is possible to accurately estimate energy use from

low power modes and its relative importance. The merits of measuring power levels of products in the field and in the lab were discussed.

Jim McMahon then asked the group to list and vote on the key research areas. In the beginning, the group was asked to simply propose areas. These were displayed in the front of the room.[4] Then Jim asked the group to vote. In the first round of votes, the group appeared strongly in favor of obtaining more behavioral information. However, people seemed to have differing concepts of what exactly behavioral research was. Some wanted to survey consumers to see how they used products with low power modes and how much they valued the services available from the product while in low power modes. Others viewed behavior more mechanistically, that is, surveying consumers to learn how many products were actually plugged in (as opposed to collecting dust in the garage), how many were connected to switchable power strips, how many occupants enabled sleep modes and for how many hours, etc. There was not sufficient time to reconcile these different views but a large portion of the Group clearly felt behavioral research was an essential element of any research agenda into low power modes.

In the second round, the mood appeared to shift to measurement and investigating specific technologies. There was also some confusion about if the research applied to commercial or residential buildings only or to both sectors. In the end, the research areas receiving the greatest interest were:

1. Obtain measurements of energy use from low power modes in a statistically valid sample of homes,. The Group felt that test procedures and building measurement protocols were sufficiently developed that this work could begin without much preparatory work. The Group discussed additional kinds of information that should be collected, such as user behavior, presence of power strips, unused products that were unplugged but not yet discarded, etc. Direct measurements of the products represented a small part of the overall measurement protocol.

2. For commercial buildings, obtain measurements of energy use from low power modes. The Group felt that our knowledge of commercial buildings lagged far behind what we know for the residential sector. There were no accepted definitions, test procedures, or overall building measurement protocols. An important first step would be to develop a taxonomy of products with low power modes because we lacked even an understanding of the scope of products with low power modes in commercial buildings.

3. Understanding efficiency opportunities and limitations of power supplies.

4. Determining the technical potential for conservation in key products and establishing supply curves of conserved energy

[4] The full list is available at the workshop website.

5. Tracking, metering, and reporting low power modes for new products. This activity would also include evaluating functionality and might even include making the measurements publicly available.

6. Communications protocols for networked appliances (especially TV and home networks). Develop communications protocols that will allow set-top boxes to enter much lower power modes when not active.

7. Investigation of technologies to provide desired functionality at ultra-low power levels.

Upon reflection, the group recognized that it would be impossible to meter buildings before establishing a measurement protocol for whole buildings and test procedures for individual devices.

Closing Comments

Don Aumann (CEC) and John Wilson (CEC) closed the afternoon session. They thanked the participants for their time and valuable contributions. They stressed that the CEC had not yet committed itself to supporting research on low-power modes, but indicated that the size and diversity of interest in this topic certainly will influence the decision. John Wilson thought that there was, at a minimum, reason to take action on power supplies, although the exact nature of those actions was still to be decided.

Individual discussions continued for some time afterwards at the conference center and then, later, at the dinner meeting. There, the tables reviewed topics raised at the day's sessions. The general consensus appeared to be that a strong case had been made to undertake research in the area of low power modes.

Documents available at the website: http://standby.lbl.gov/CEC_Workshop/

- Summary of workshop
- List of attendees
- Agenda
- Bruce Nordman's talk on terms
- Alan Meier's review of the literature
- Alan Meier's slides summarizing the literature review
- Ecos Consulting's report on power supplies
- Bruce Nordman's slides on standard controls
- Leo Rainer's calculations for the Livermore house
- List of research topics considered by the Workshop participants
- The draft IEC draft defining standby power and a test method